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(54) **SYSTEM FOR COOLING A SAMPLE IN AN APPARATUS FOR PROCESSING THE SAMPLE**

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(57) **ABSTRACT**

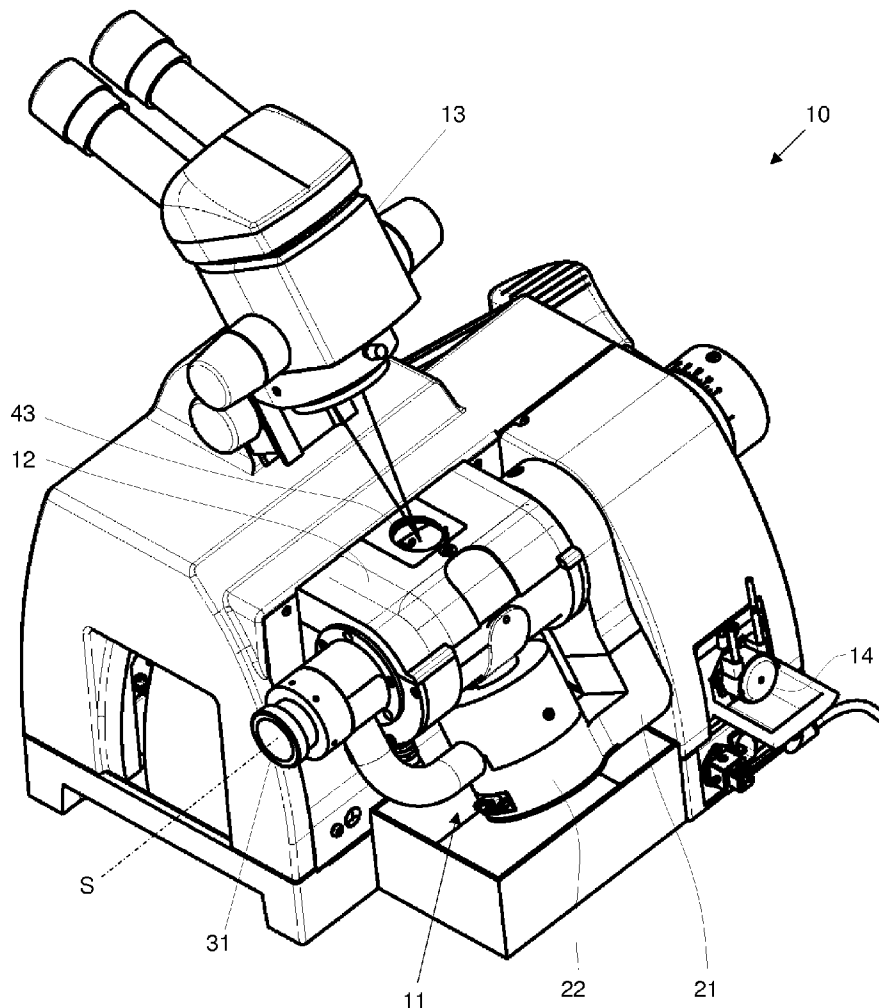
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For cooled processing of a sample, a system for cooling the sample includes a holding device (22) for receiving the sample in a sample holder (20), as well as a cooling chamber (12) that surrounds the position (P) of the sample mounted on the holding device. Provided in the cooling chamber (12) is a window through which a tool receptacle (16) for receiving a tool (W) for processing the sample projects into the cooling chamber (12). The holding device (22) is coolable to a settable temperature by means of a fluid coolant, and ensures cooling of the sample. For this, a coolant, e.g. liquid nitrogen, flows through a coolant conduit of the holding device (22), which conduit is furnished with the coolant at the input end (31) and opens at the output end (41) into the cooling chamber (12), which in this fashion is filled with coolant gas.

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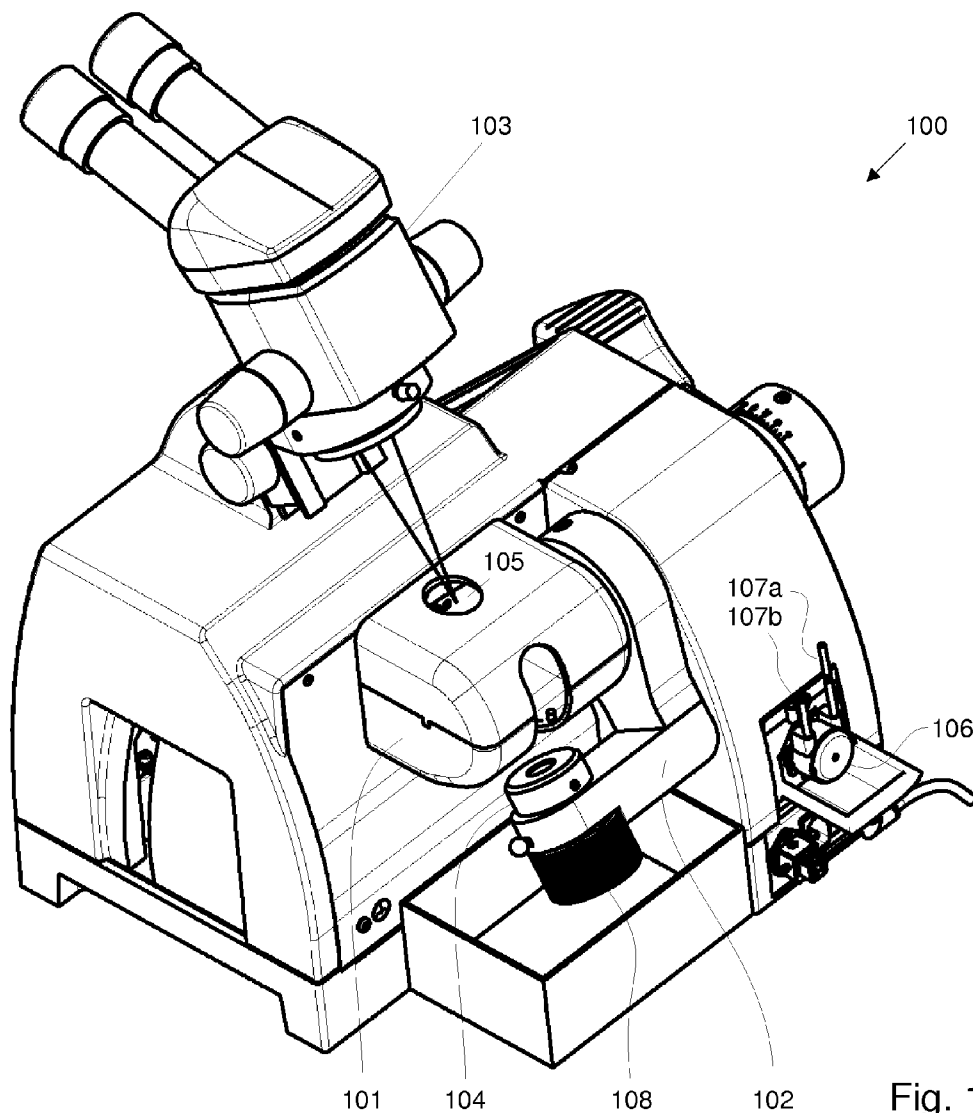


Fig. 1
(Prior Art)

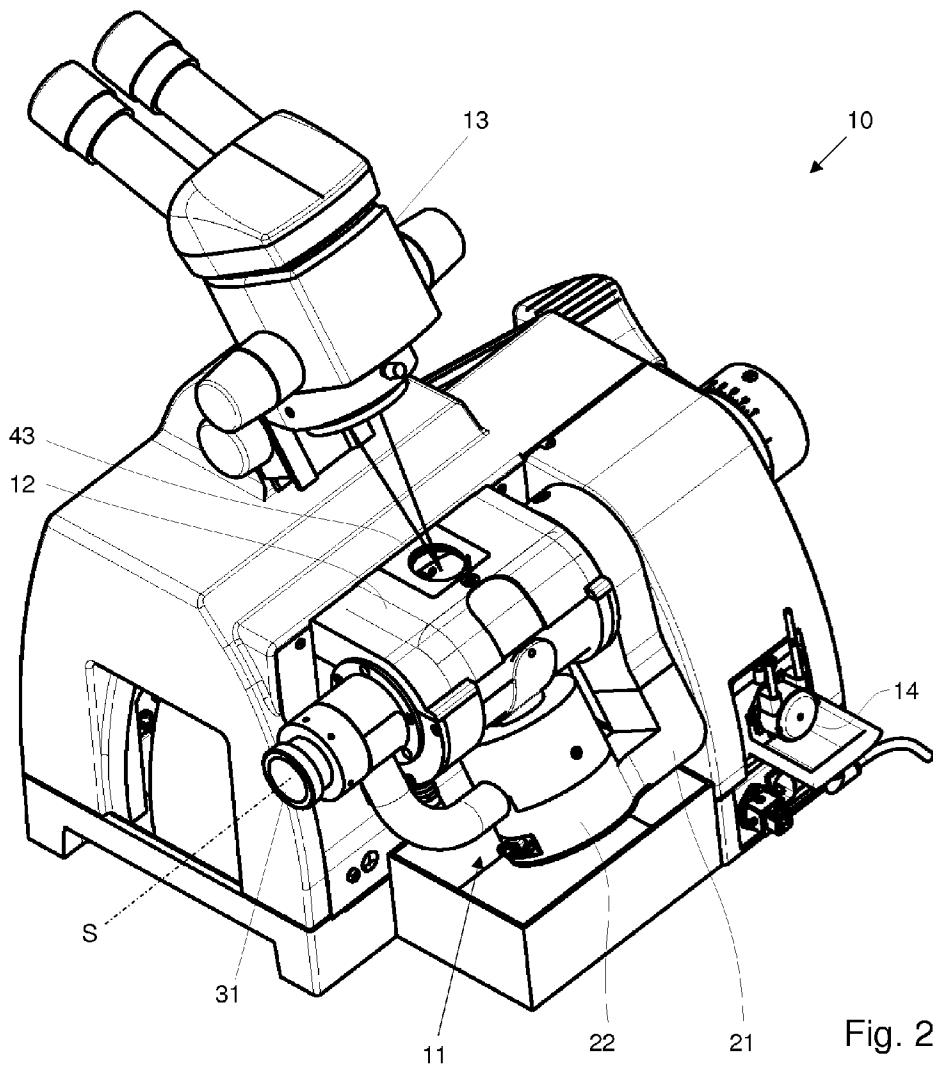


Fig. 2

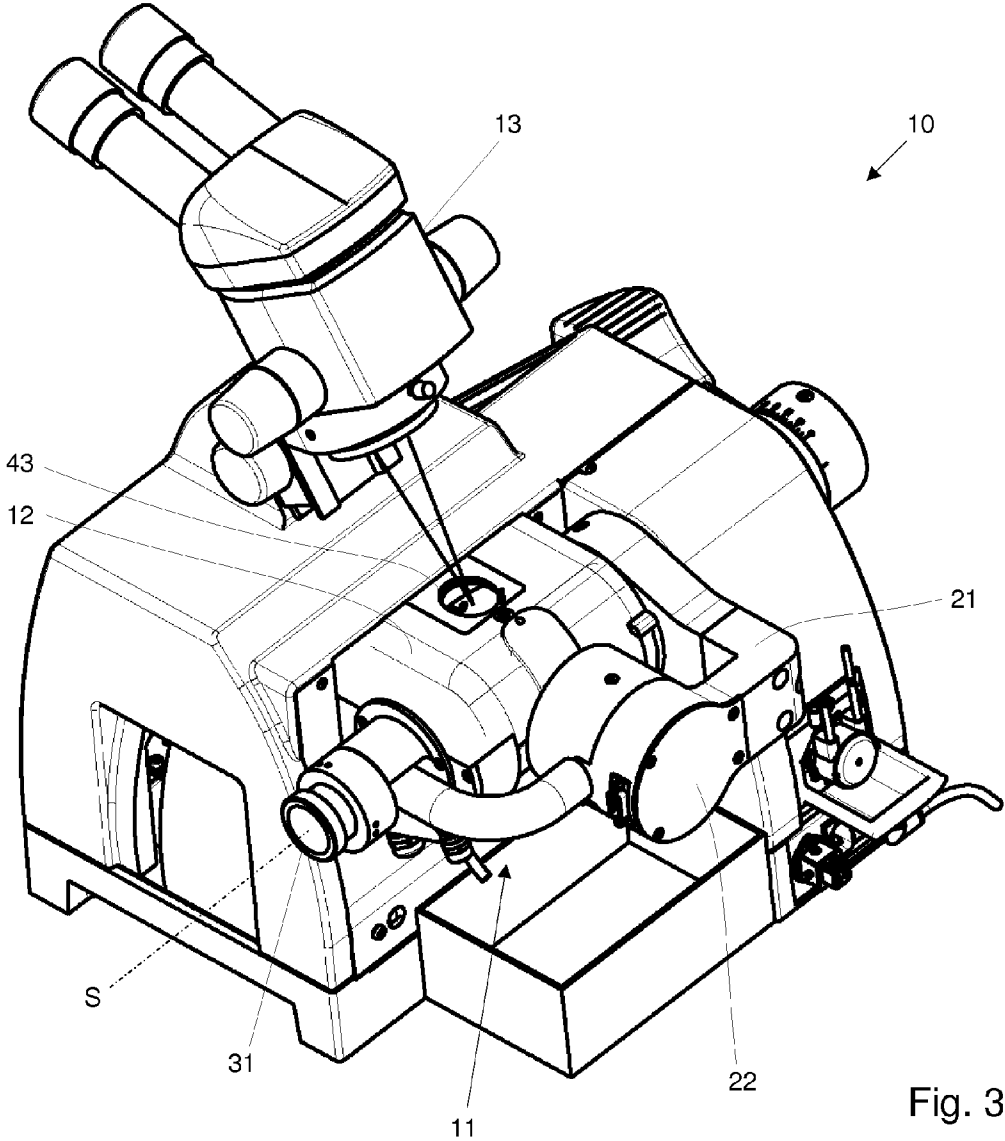


Fig. 3

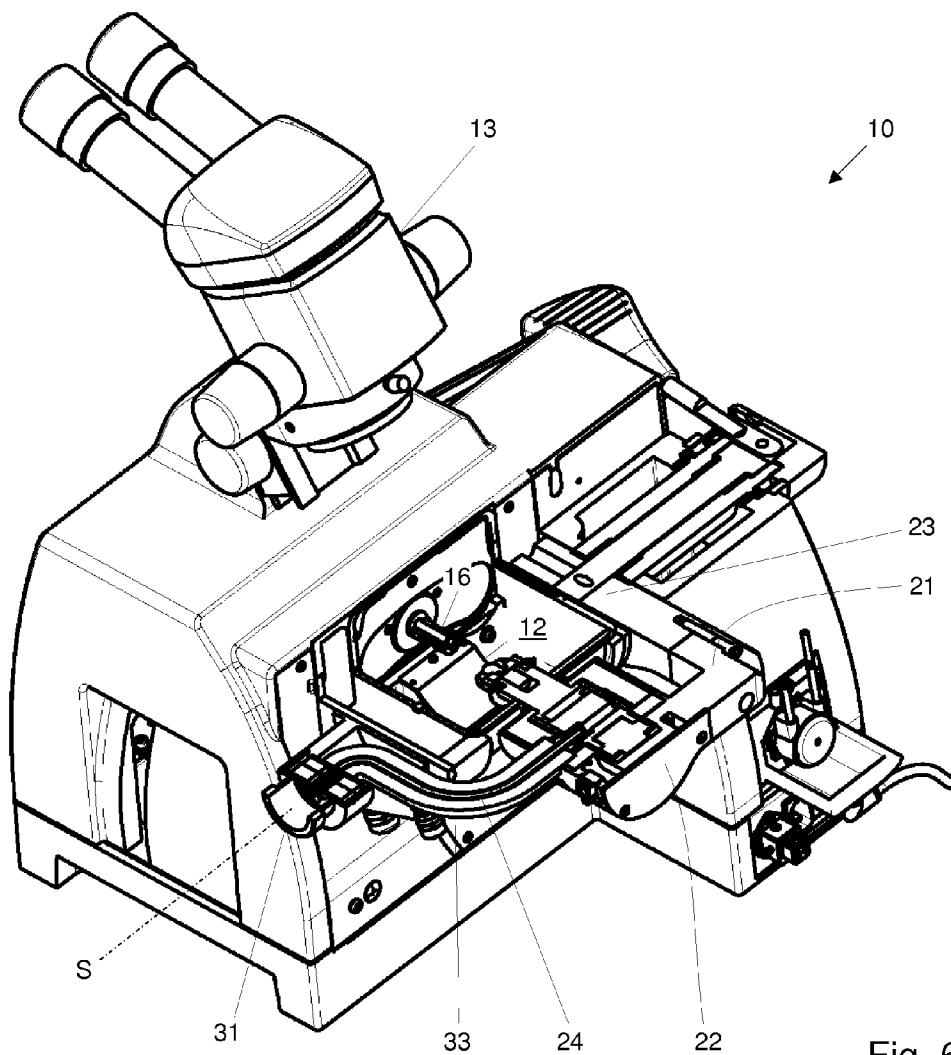
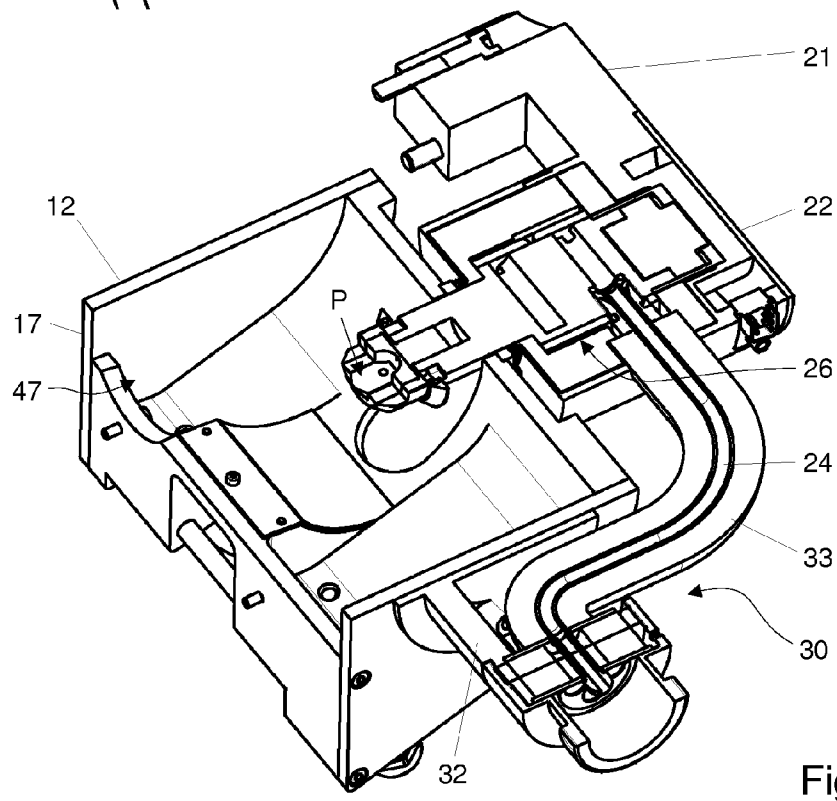
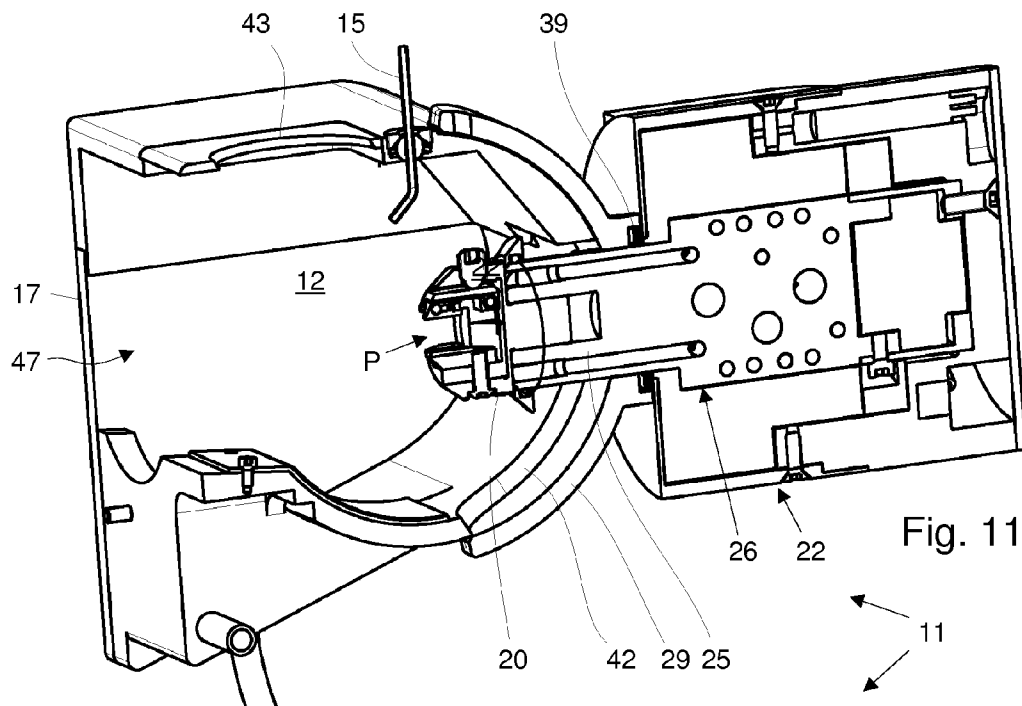


Fig. 6



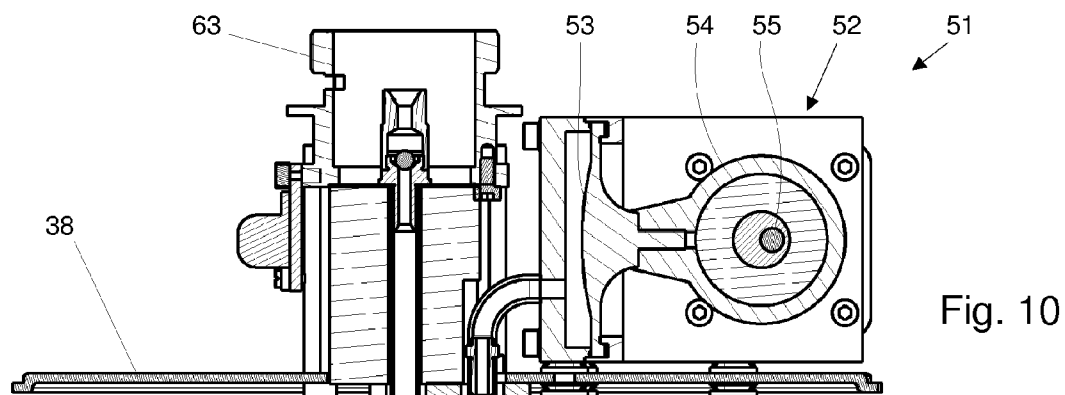


Fig. 10

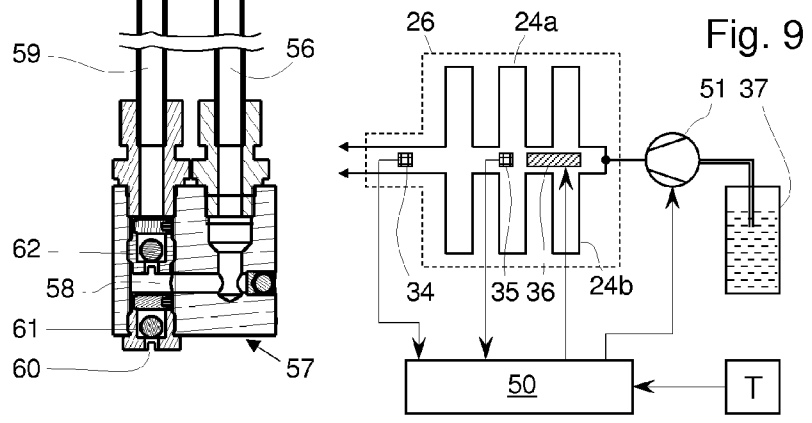


Fig. 9

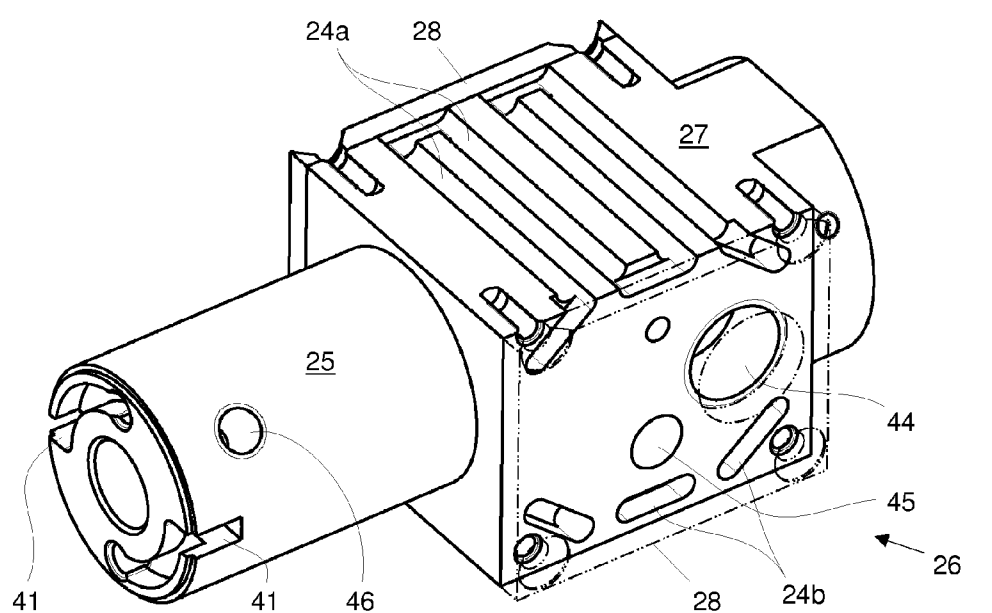


Fig. 8

**SYSTEM FOR COOLING A SAMPLE IN AN
APPARATUS FOR PROCESSING THE
SAMPLE**

CROSS REFERENCE TO RELATED
APPLICATIONS

[0001] This application claims priority of Austrian patent application number A 1762/2011 filed Nov. 29, 2011, the entire disclosure of which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] The invention relates to the processing of samples under cooled conditions. The invention further relates to a system for cooling a sample for processing of the sample in a processing device.

BACKGROUND OF THE INVENTION

[0003] Processing apparatuses of the kind recited are manufactured for the preparation of samples in particular for producing microtome sections. For this, for example, tissue samples to be investigated are embedded in synthetic resin and these samples are processed by means of a milling cutter into the shape of truncated pyramids (so-called "trimming"). The samples trimmed in this fashion are then sectioned in a microtome, with the result that tissue sections having a thickness in the micrometer or nanometer range are obtained, which can then be investigated.

[0004] The Applicant has developed a unit suitable for such purposes, which is described in EP 1 923 686 A2=US 2008-0115640 A1 and is already on the market in an implementation under the designation "Leica EM TXP." FIG. 1 is a perspective view of this unit 100. Housed inside a cover 101 is a processing tool (not visible in FIG. 1; e.g. milling cutter, saw, grinding disc) with which a prepared sample to be processed (hereinafter a "sample") is processed. The sample is located, for example, on a sample holder (not shown) that is held by a sample receptacle 104 and projects into cover 101 through an opening 105 thereof.

[0005] Cover 101 serves as an accidental contact protector during sample processing. The lower part of cover 101 can moreover be used as a collection pan for polishing agent or other liquids that are directed onto the sample. The upper part of cover 101 is transparent and removable; it is equipped with a switching element that interrupts rotation of the tool is the cover is removed.

[0006] Apparatus 100 comprises an observation device 103, for example a stereomicroscope, that serves for viewing of the sample. If applicable, a measurement device that enables monitoring and/or measurement of the sample can be provided in the observation device. In a preferred variant of the invention, for example, a measuring eyepiece is used in the stereomicroscope; with this the sample itself, but also the progress of the processing action, can be accurately measured. Other systems, such as e.g. video cameras and the like, can also be utilized as observation device 103.

[0007] To allow the sample to be cooled or lubricated during processing, unit 101 can be equipped with a pump 106; via an inflow 107a, a cooling or lubricating agent is delivered (from a reservoir container, not depicted) to pump 106 and is conveyed via an outflow 107b from pump 106 to the sample.

[0008] Sample mount 104 is held in an arm 102 that is pivotable around a horizontal axis S that extends perpendicular to the viewing direction of observation device 103. The

pivoting of sample mount 104 by means of the arm allows the sample to be brought into different working positions, for example a measurement position, a processing position, and a monitoring position.

[0009] In the processing position (which is not shown in FIG. 1, but see FIG. 3) the longitudinal axes of sample receptacle 104 and of the clamping apparatus for the processing tool lie substantially parallel to one another; in the unit shown, the two longitudinal axes are then located horizontally. FIG. 1 depicts the monitoring position, in which sample receptacle 104 is pivoted downward from the processing position and the sample surface is thus positioned exactly in the beam path of stereomicroscope 103. This enables optical monitoring and analysis of the sample surface. The sample mount is rotatable in sample receptacle 104 around its longitudinal axis, which extends perpendicular to axis S. The sample can thus be rotated by means of a rotary knob 108 in such a way that all regions of the sample can be viewed through stereomicroscope 103, and/or edges of the sample can be processed. In the additional measuring position, which is located, for example, approximately 20° above the processing position, precise measurement of, for example, the sample edges is possible using suitable measuring apparatuses in observation device 103.

[0010] This known unit of the Applicant is, however, like other conventional units of this kind, designed principally for processing hard samples or at least dimensionally stable samples, and not for processing samples that are soft at room temperature.

[0011] Processing of samples at low temperatures is described, for example, in the Applicant's DE 40 28 806 C2=U.S. Pat. No. 5,299,481, which discloses a microtome having a cooling chamber accessible from above. Cooling of the sample and of other cooled parts in the cooling chamber occurs here exclusively by way of the gaseous cryogen with which the chamber is charged. This prevents the deposition of moisture from the environment onto the sample as ice (as a result of displacement by the gas), as well as direct contact by the sample with cooling liquid; but it does considerably complicate reliable setting of the sample temperature, and limits the achievable cooling performance.

SUMMARY OF THE INVENTION

[0012] It is therefore an object of the invention to make possible the processing of samples while the samples are cooled to a desired settable temperature, while at the same time condensation of cooling liquid and/or moisture/ice on the sample and the sample environment is to remain precluded.

[0013] The stated object is achieved by a system for cooling a sample of the kind mentioned earlier, in that according to the present invention, the holding device can be cooled to a settable temperature by means of a fluid coolant, the holding device comprising a coolant conduit through which the coolant can flow and which for that purpose is furnished with the coolant at the input end and opens into the cooling chamber at the output end; in addition, there is provided in the cooling chamber a window through which a tool receptacle (of the sample processing apparatus), which serves to receive a tool for processing the sample, is positionable in a manner projecting into the cooling chamber, and in that context usefully is arranged without contact with the chamber.

[0014] The stated object is likewise achieved according to the present invention, in the context of the processing of samples under cooled conditions, by a method having the steps of:

[0015] receiving a sample to be processed, in a sample holder, onto a holding device of the apparatus,

[0016] cooling the sample, and

[0017] processing the sample with the aid of at least one tool clamped in the apparatus, such that sample cooling and sample processing can of course in most cases be carried out in overlapping fashion, the sample being cooled via the holding device, which in turn is cooled by means of a fluid coolant to a settable temperature, the coolant flowing through a coolant conduit of the holding device, which conduit is furnished with the coolant at the input end, and at the output end opens into a cooling chamber that surrounds the sample during processing.

[0018] This approach allows the stated object to be achieved in surprisingly efficient fashion. Cooling of the sample occurs not as a result of contact with coolant, but by heat transfer via the holding device. The interior of the chamber is filled only with coolant gas, which serves less for cooling than for the displacement of (as a rule, moist) ambient air, which avoids undesired condensation of moisture as ice. The tool as such is not cooled (only indirectly via the coolant gas inside the chamber); cooling of the tool is dispensable, and results in a simplification of the configuration of the apparatus.

[0019] According to an aspect of the invention it is advantageous, as already indicated, if the cooling chamber is designed to hold in its interior a gas atmosphere that is constituted by the coolant and surrounds at least the sample. For this, after cooling the holding device the coolant can flow into the cooling chamber, and can create therein a cold gas atmosphere. Outflow of the gas can be enabled by the fact that the cooling chamber comprises, in addition to a window, an opening that is arranged on the upper side of the cooling chamber, although the cooling chamber is otherwise (i.e. aside from the aforesaid window and the opening) substantially closed off from the environment of the apparatus. "Substantially closed off" means here that the chamber comprises no openings that, when the processing system is in the operating state, permit an inflow of ambient air or the like, although minor gaps, e.g. between movable parts, can be permitted if, for example, coolant gas can penetrate through them to a sufficient extent and thereby suppress any inflow of gases from outside. The cooling chamber can thus contain a gas atmosphere that is constituted by the coolant and surrounds at least the sample.

[0020] In order to allow reliable setting of the temperature of the sample on the holding device, a temperature control system can be provided which is designed to guide a liquid cryogen, in particular liquid nitrogen, in the coolant conduit and evaporate it, and to allow only gaseous cryogen to travel into the cooling chamber. A temperature sensor associated with the temperature control system, which sensor is arranged at the output end of the coolant conduit in order to monitor the passage of liquid cryogen, is suitable for preventing the cryogen from traveling in a liquid state into the cooling chamber.

[0021] For provision of the coolant, the coolant conduit can comprise at the input end a coolant connector that is designed for connection of a coolant line of an external coolant vessel.

[0022] In a particularly advantageous refinement of the invention, the holding device is arranged on a pivot arm that enables pivoting of the sample around a pivot axis with

respect to the tool receptacle. The pivot arm can be arranged outside the cooling chamber, such that a base of the holding device and/or the sample holder projects through an opening into the cooling chamber. This opening can furthermore be closed off by a shield that is pivotable together with the holding device or the sample holder. The previously mentioned coolant connector can moreover be oriented coaxially with the pivot axis. In a favorable embodiment, the arrangement of the coolant connector and pivot arm can be such that the pivot arm is held by a joint located to the side of the cooling chamber, and the coolant connector is arranged on that side of the cooling chamber which is located opposite the joint.

[0023] According to a further aspect of the invention, the system for sample cooling is removable, so that the cooling chamber together with the holding device and pivot arm is embodied in a sample cooling arrangement that is removable from the sample processing apparatus. In the context of a removable system, the cooling chamber can have a connection interface by way of which it is detachably mountable on the aforementioned apparatus for processing samples; the aforesaid window, through which a tool receptacle projects in the state mounted on the apparatus, is provided in this context inside the connection interface.

[0024] A further aspect of the invention relates to an apparatus for processing samples of the kind recited earlier, in which apparatus the holding device together with a cooling chamber is embodied in accordance with the above-described system according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention, along with further details and advantages, will be explained below with reference to an exemplifying embodiment, namely a sample processing apparatus having an arrangement for sample cooling that is removable as an add-on unit, which arrangement is shown in the appended drawings. In the individual drawings, in schematic form:

[0026] FIG. 1 is a perspective view of a processing apparatus of the existing art;

[0027] FIG. 2 is a perspective view of the processing apparatus in accordance with the exemplifying embodiment, having a mounted arrangement for sample cooling in the monitoring position for observation of the sample;

[0028] FIG. 3 shows the processing apparatus of FIG. 2 in the processing position;

[0029] FIG. 4 is a perspective view of the arrangement in the removed state;

[0030] FIG. 5 is a detail view of the arrangement in the processing position;

[0031] FIG. 6 shows the processing apparatus as in FIG. 3, although here the arrangement is shown in a sectioned depiction (horizontal section);

[0032] FIG. 7 shows the arrangement as in FIG. 4, but in a sectioned depiction with a horizontally extending section plane;

[0033] FIG. 8 is a perspective view of the cooling block of the arrangement;

[0034] FIG. 9 is a block diagram of the temperature regulator;

[0035] FIG. 10 is a sectioned view of the coolant pump; and

[0036] FIG. 11 shows the cooling chamber and cooling block in a further sectioned view with a vertically extending section plane.

DETAILED DESCRIPTION OF THE INVENTION

[0037] The exemplifying embodiment described below represents a further development of the unit discussed earlier with reference to FIG. 1, in which the cover and sample mount are now embodied as a combinedly removable device with sample cooling. Be it noted that the embodiment shown is not to be understood as a limitation of the invention; one skilled in the art can instead effect numerous variations and configurations of the invention.

[0038] Referring to FIGS. 2 and 3, a sample processing apparatus 10 according to the present invention with sample cooling is shown. In the Figures, the apparatus is equipped with a removable arrangement 11 for sample cooling, which at the same time contains a cooling chamber 12 that surrounds the sample during processing; the basic body of the apparatus corresponds to the sample processing apparatus (e.g. of the "Leica EM TXP" type) described earlier with reference to FIG. 1, without cover and sample holder including the pivot arm. The description given above with regard to the apparatus of FIG. 1, in particular with regard to the various working positions and the associated processing of the sample, and to the observation device (stereomicroscope), thus applies in the same fashion, aside from the sample cooling made possible according to the present invention, to the apparatus according to the present invention, and reference is made in supplementary fashion to the description in the Applicant's EP 1 923 686 A2 (or US 2008/0115640 A1) and DE 10 2006 054 609 A1 (or US 2008/0118312 A1), both of which are herewith incorporated in their entirety as part of the present disclosure.

[0039] Apparatus 10 further comprises, as already mentioned earlier, an observation device 13 (e.g. stereomicroscope) as well as a pump 14 with which the sample can be supplied with a liquid during processing; for processing with grinding discs, for example, a low-temperature-compatible liquid can be introduced as a grinding agent for wet grinding. Tube 15 can be guided, on the upper side of the cooling chamber, through a separate opening in order to bring the liquid to position P of the sample. The lower part of chamber 12 can in turn serve as a collection pan for said liquid. It is significant in this context that in the processing position, the sample and the tool are held in substantially horizontal axes, since this allows excess grinding liquid to flow off quickly and decreases undesired deposition of solids.

[0040] Arrangement 11 for sample cooling is shown in FIG. 4 in the removed state. The removable unit 11 performs essentially two tasks, for the implementation of which two assemblies respectively corresponding to the tasks are provided:

[0041] 1. Delimiting the processing space: A cooling chamber 12 comprises a temperature-regulated outer wall and a shield 29 for sealing the pivotable sample holder 20. An opening 43 on the upper side of the chamber allows the prepared sample to be observed, and furthermore serves to allow evaporated coolant gas to flow out in controlled fashion.

[0042] 2. Prepared sample cooling: A pivot arm 21, which is pivotable around the horizontal axis S (pivot axis) extending through the cooling chamber, contains a holding device 22 for positioning a sample holder 20 (FIG. 5). Holding device 22 is equipped with a cooling block having flowthrough conduits for a coolant, preferably a cryogenic liquid such as liquid nitrogen. The coolant is evaporated and travels into the cooling chamber through an outlet opening for the cold gas.

[0043] Arrangement 11 thus integrates the components of the system according to the present invention for sample cooling into a system that advantageously is removable as a unit.

[0044] Arrangement 11 is mounted on apparatus 10 by means of a connection interface 17 that is embodied on chamber 12 and that surrounds a window 47. Upon mounting onto apparatus 10, the chamber is positioned like a cap over tool receptacle 16, so that the tool receptacle projects through window 47 into the interior of chamber 12 but without touching components of the chamber. A tool mounted on tool receptacle 16 can thus move freely inside window 47 to the extent necessary for processing the sample.

[0045] Arrangement 11 can be brought with the aid of pivot arm 21 into a variety of working positions, e.g. a processing position (FIG. 3) and a monitoring position (FIG. 2) for observing the prepared surface of the processed sample. Pivot arm 21 is fastened pivotably on processing apparatus 10 by way of a joint 23 that is arranged on one side of cooling chamber 12. In the embodiment shown, joint 23 is mounted permanently on processing apparatus 10, and a detachable connecting point is located between the joint and pivot arm (see FIGS. 4 and 7).

[0046] FIG. 5 is an enlarged partial view of arrangement 11 (mounted on the apparatus) in the processing position, the upper part of cooling chamber 12 having been removed for clarity (the removed part is depicted with dashed lines). The previously mentioned tool receptacle 16, e.g. in the form of a collet chuck, is provided for receiving a processing tool (at position W), and is rotatable around its longitudinal axis at a settable rotation speed, and positionable in the direction of that longitudinal axis. In addition, the entire tool receptacle 16 can be displaced laterally with respect to the position of the sample, e.g. for eccentric grinding; actuation of this displacement motion occurs laterally on the housing, as described in more detail in DE 10 2006 054 609 A1 or US 2008/0118312 A1.

[0047] The sample is positioned at a predefined position P with respect to tool W or tool receptacle 16 with the aid of a sample holder 20. The sample is symbolized here by its position P. Sample holder 20 is embodied preferably as a separate detachable component, and is fastened in a holding device 22 so that a sample present on sample holder 20 is entirely located in the interior of cooling chamber 12. Holding device 22 is held by pivot arm 21 at a distance from pivot axis S and comprises a base 25, oriented with respect to the pivot axis, which projects through a passthrough opening 42 into chamber 12 and whose inwardly directed end is set up for fastening and cooling of sample holder 20 together with the sample.

[0048] Referring again to FIG. 2, arrangement 11 comprises a connector piece 30 having a connector 31 for the delivery of liquid nitrogen (LN₂) that serves as a coolant. This connector 31 serves as a coolant connector for detachable connection to a filling hose (plastic with insulation, of known type). The filling hose is in communication, for example, with an external coolant reservoir, e.g. an LN₂ dewar.

[0049] FIGS. 6 and 7, in which arrangement 11 is shown in a sectioned depiction (with a horizontal section plane along pivot axis S), illustrate the layout of conduit 24 for conveying the coolant or liquid nitrogen to holding device 22. The liquid nitrogen travels through connector piece 30 via a hose part 33 into holding device 22. The connector piece 30, hose part 33, and holding device 22 are thermally insulated on the outside.

[0050] Connector 31 is preferably embodied coaxially with pivot axis S, by the fact that is located rotationally symmetrically with its axis in pivot axis S, and permits a rotation with respect to base part 32, attached to the chamber, of connector piece 30. The result is that the hose connector remains stationary even in the context of rotation of the sample mount; the rotation in connector piece 30 occurs between base part 32 and the attached part (FIG. 4) carrying connector 31. The connector connection is thereby decoupled from pivoting motions of pivot arm 21. This increases security, avoids damage to the filling hose upon pivoting as well as undesired motions of the coolant reservoir, and facilitates stable positioning of the processing apparatus. The connector connection can be embodied with a non-rotating coolant hose connection of known type. Connector piece 31 is located on cooling chamber 12 preferably opposite the position of joint 23 of the pivot arm.

[0051] The liquid nitrogen flows along conduit 24 through holding device 22 in a cooling block 26, evaporates there, and travels as a cold gas through base 25 into cooling chamber 12. The pump for conveying liquid nitrogen (not shown) is regulated, with the aid of temperature sensors and using a heating device (see below with reference to FIG. 9), in such a way that only gaseous nitrogen travels into the cooling chamber. Gaseous nitrogen has two advantages: on the one hand, as a cold gas, it cools the chamber and processing tools. Secondly, the chamber is purged with the dry gas, and the formation of ice crystals on the cold surfaces and on the sample is thus prevented. The gas emerges principally via observation opening 43 located on top.

[0052] FIG. 8 shows cooling block 26 in a separate perspective view; the left side portion of the cooling block is removed in FIG. 8, and in addition the upper side of the cooling block is removed, making visible the meandering layout of coolant conduit 24. A heating cartridge 34 is housed in an orifice 44 of the cooling block, and a (first) temperature sensor 35 in a second orifice 45. Multiple orifices are introduced into the body of cooling block 26 on the upper and the lower side of the cooling block, the ends of each pair of orifices being connected by depressions, with the result that a conduit extending back and forth between the left and right side of the cooling block is formed, serving as a coolant conduit 24. The depressions are closed off by side parts 28 that are respectively attached on the left and right like a cover, thus producing a linear conduit that here is split into two branches (upper and lower branch 24a, 24b). At the outlet end the two branches of conduit 24 are guided through the base and lead to exit openings 41 at that end of the base at which sample holder 20 is also attached. The conduit thus opens at the output end (namely, with both branches) into coolant chamber 12.

[0053] FIG. 9 is a block diagram of the control system for setting a desired temperature T of the sample by means of a temperature control loop having heating system 34 and temperature sensor 35. This control loop, as well as thermal insulation with respect to the unit, enables a desired sample temperature to be set, in conjunction with a control unit (temperature control system 50) for setting the desired sample temperature with a heat-up function after processing is complete. The heating system also makes it possible to avoid condensation of ambient moisture on the outer side of cooling chamber 12 and holding device 22. An LN₂-compatible coolant pump 51 delivers liquid nitrogen, provided from coolant reservoir 37, to the cooling block.

[0054] Referring to FIG. 10 (sectioned view), pump 51 is [implemented], for example, by means of a membrane pump 52 that is embodied on cover plate 38 of LN₂ reservoir 37 with a pump head 57, immersed into the coolant, that is located in a manner immersed into the liquid nitrogen preferably close to the bottom of the LN₂ reservoir. As a result of the design selected here, membrane pump 52 is located with its rubber membrane 53 outside the LN₂ reservoir and is separated from the valves in pump head 57 and particular from the cold liquid. Membrane 53 is moved back and forth by an eccentric motor 54 (that moves around axis 55). The result is to produce a moving gas column in pump tube 56 that connects membrane pump 52 to pump head 57, and a (slight) positive and negative pressure is thus alternately generated in pump headspace 58 at the end of pump tube 56, with the result that two valves 61, 62 located in pump head 57 alternately open and close in order to convey LN₂. Each of the two valves 61, 62 is embodied in the form of a ball having a conical sealing seat, and in the pressureless state is closed by the dead weight of the relevant ball. First valve 61 serves as an inlet valve; it connects between an inlet opening 60 to the liquid space of reservoir 37 and pump headspace 58, and opens when there is negative pressure in the latter. Second valve 62, here referred to as a "delivery valve," connects pump headspace 58 to a riser tube 59; it opens when there is positive pressure in pump headspace 58. When there is negative pressure in pump headspace 58, in a first step of a pumping operation liquid nitrogen flows through the inlet valve. In the next step, when a positive pressure is produced in pump headspace 58 by membrane pump 52, inlet valve 61 closes while delivery valve 62 is opened, and the liquid is forced into riser tube 59. When the pump headspace is once again brought to negative pressure in a new cycle, delivery valve 62 closes again and the cycle begins ab initio. Riser tube 59 leads through cover plate 38 and opens at its upper end into a connector 63 for the coolant hose (not shown), which is connected to connector 31 of sample cooling arrangement 11. The delivery capacity can thus be very accurately regulated by way of the rotation speed of membrane pump 52; eccentric motor 54 of the membrane pump is operated, for example, as a stepping motor. At the same time, the mechanism of pump head 57 is very robust and insensitive to temperature changes and icing.

[0055] Nitrogen delivery via coolant pump 51 is controlled as a function of the setpoint temperature T. The rotation speed ranges of pump 51 are defined in the software of temperature control system 50 in such a way that for each settable value of the setpoint temperature, the liquid nitrogen becomes gaseous within the meanders of conduit 24. The resulting nitrogen gas is guided through openings 41 into chamber 12 and acts as a protective gas against ice deposits on the cold surfaces in the interior of the chamber. Heating system 35 is operated at only low output, and serves to increase the control accuracy and temperature consistency; without a heating system, the temperature would be several K below the setpoint temperature.

[0056] A second temperature sensor 36, preferably arranged close to exit openings 41, for example in a separate orifice 46, can be provided in order to prevent liquid nitrogen from getting into the cooling chamber, said sensor. If the temperature at temperature sensor 36 drops below the temperature of liquid nitrogen, or more precisely to a limit value just thereabove, the nitrogen is converted into the gas phase by additional heating.

[0057] The chamber and other external surfaces can additionally be heated in order to prevent the condensation of water.

[0058] FIG. 11 shows arrangement 11 in a sectioned view, with a horizontal section through the longitudinal axis of the holding device. In this sectioned depiction, conduit 24 in cooling block 25 is visible in multiply sectioned fashion because of its meandering layout.

[0059] Consistent with pivotability, a geometry of passthrough opening 42 for the sample holder as an elongated or slot-shaped opening is useful. A shield 29 that is prolonged in wing-like fashion along the pivoting direction on both sides is provided on base 25 in order to close off opening 42 in the various working positions. Passthrough opening 42 is closed off by shield 29 in every pivot position, and undesired emergence of cold gas at this point is suppressed. Provided at the attachment of shield 29 are wave spring washers 39 that counteract lifting of the shield away from the edge of opening 42.

[0060] With the aid of the invention it is possible to process samples that are too soft for processing at room temperature, by cooling them to a temperature at which said processing is possible, for example below an associated glass transition temperature. A typical temperature range for processing is, for example, -120°C . to 170°C . Examples of sample materials for which the invention enables processing are, for example, polymer- or rubber-based samples (e.g. structures made of wire or the like embedded in rubber material), as well as biological samples.

[0061] The invention is not to be limited to the specific embodiments disclosed, and modifications and other embodiments are intended to be included within the scope of the invention.

PARTS LIST

[0062] 10 Apparatus for sample processing
 [0063] 11 Sample cooling arrangement
 [0064] 12 Cooling chamber
 [0065] 13 Observation device/stereomicroscope
 [0066] 14 Pump
 [0067] 15 Tube
 [0068] 16 Tool receptacle
 [0069] 17 Interface
 [0070] 20 Sample holder
 [0071] 21 Pivot arm
 [0072] 22 Holding device
 [0073] 23 Joint
 [0074] 24 Conduit for coolant
 [0075] 25 Base (cooling block)
 [0076] 26 Cooling block
 [0077] 27 Body (of cooling block)
 [0078] 28 Side part (of cooling block)
 [0079] 29 Shield
 [0080] 30 Connector piece
 [0081] 31 Coolant connector
 [0082] 32 Base of connector piece
 [0083] 33 Hose part
 [0084] 34 Heating system/heating cartridge
 [0085] 35 First temperature sensor
 [0086] 36 Second temperature sensor
 [0087] 37 Reservoir
 [0088] 38 Cover plate of reservoir
 [0089] 39 Wave spring washers
 [0090] 41 Exit opening

[0091] 42 Passthrough opening
 [0092] 43 Observation opening
 [0093] 44, 45, 46 Orifices
 [0094] 47 Window
 [0095] 50 Temperature control system
 [0096] 51 Coolant pump
 [0097] 52 Membrane pump
 [0098] 53 Membrane
 [0099] 54 Eccentric motor
 [0100] 55 Eccentric axis
 [0101] 56 Pump tube
 [0102] 57 Pump head
 [0103] 58 Pump headspace
 [0104] 59 Riser tube
 [0105] 60 Inlet opening
 [0106] 61 Inlet valve
 [0107] 62 Delivery valve
 [0108] 63 Connector for coolant hose
 [0109] S Pivot axis
 [0110] P Position of sample
 [0111] W Tool
 [0112] T Setpoint temperature
 [0113] 100 Apparatus (existing art)
 [0114] 101 Cover
 [0115] 102 Arm (pivot arm)
 [0116] 103 Observation device/stereomicroscope
 [0117] 104 Sample receptacle
 [0118] 108 Rotary knob for sample mount
 [0119] 105 Opening (in cover)
 [0120] 106 Pump
 [0121] 107a, 107b Inflow and outflow of pump
 [0122] 108 Rotary knob for sample mount

What is claimed is:

1. A system for cooling a sample for processing of the sample in a processing device, comprising:

- a holding device configured to receive a sample for processing via a sample holder;
- a cooling chamber including a window, the cooling chamber surrounding the position of the sample mounted on the holding device;
- a tool receptacle configured to receive a tool for processing the sample, the tool receptacle being positionable through the window such that it projects into the cooling chamber; and

wherein the holding device is coolable to an adjustable nominal temperature by a fluid coolant, the holding device comprising a coolant conduit through which the fluid coolant can flow, the coolant conduit having an input end configured to supply the fluid coolant and an output end that opens into the cooling chamber.

2. The system according to claim 1, wherein the cooling chamber is configured to hold in its interior a gas atmosphere that is constituted by the coolant and surrounds at least the sample.

3. The system according to claim 2, wherein the cooling chamber comprises, in addition to the window, an opening that is arranged on the upper side of the cooling chamber, while the cooling chamber is otherwise substantially closed off with respect to the environment of the apparatus.

4. The system according to claim 1, wherein the holding device has a temperature control system configured to guide a liquid cryogen in the coolant conduit and evaporate it, and configured to guide only gaseous cryogen into the cooling chamber.

5. The system according to claim 4, further comprising a temperature sensor associated with the temperature control system, the temperature sensor arranged at the output end of the coolant conduit in order to monitor the passage of liquid cryogen.

6. The system according to claim 1, wherein the coolant conduit comprises at the input end a coolant connector configured to be connected to a coolant line of an external coolant vessel.

7. The system according to claim 1, wherein the holding device is arranged on a pivot arm that enables pivoting of the sample around a pivot axis with respect to the tool receptacle.

8. The system according to claim 7, wherein the pivot arm is arranged outside the cooling chamber, and wherein a base of the holding device and/or the sample holder projects through an opening into the cooling chamber.

9. The system according to claim 8, wherein the opening is configured to be closed off by a shield that is pivotable together with the holding device or the sample holder.

10. The system according to claim 7, wherein the coolant conduit comprises at the input end a coolant connector that is configured to be connected to a coolant line and is oriented coaxially with the pivot axis.

11. The system according to claim 10, wherein the pivot arm is held by a joint located to a first side of the cooling chamber, and the coolant connector is arranged on a second side of the cooling chamber, the second side being located opposite the first side.

12. The system according to claim 1, wherein the cooling chamber together with the holding device and pivot arm are detachably mountable as an add-on unit on an apparatus for processing samples, the cooling chamber being detachably connectable to the apparatus via a connection interface, and the window being provided in the connection interface.

13. An apparatus for processing samples, comprising:
a holding device configured to receive a sample holder, the sample holder configured to hold a sample to be processed;

an observation device for observing the sample;
a cooling chamber including a window, the cooling chamber surrounding the position of the sample mounted on the holding device;

a tool receptacle in the cooling chamber configured to receive a tool for processing the sample, the tool receptacle being positionable through the window such that it projects into the cooling chamber; and

wherein the holding device is coolable to an adjustable nominal temperature by a fluid coolant, the holding device comprising a coolant conduit through which the fluid coolant can flow and which can be supplied with the coolant at the input end and opens into the cooling chamber at the output end

14. A method for cooled processing of a sample in an apparatus for processing samples, comprising the steps of:

receiving a sample to be processed in a sample holder on a holding device of the apparatus, the holding device having a coolant conduit including an input end and an output end which opens into a cooling chamber that surrounds the sample during processing;

cooling the sample via a fluid coolant flowing through the coolant conduit on the holding device; and

processing the sample with at least one tool clamped in the apparatus.

15. The method according to claim 14, wherein after cooling the holding device, the coolant flows into the cooling chamber and creates a cold gas atmosphere therein.

16. The method according to claim 14, wherein the cooling chamber contains a gas atmosphere that is constituted by the coolant and surrounds at least the sample.

17. The method according to claim 14, wherein a liquid cryogen is guided and evaporated in the coolant conduit of the holding device, such that only gaseous cryogen travels into the cooling chamber.

18. The method according to claim 14, wherein the liquid cryogen is liquid nitrogen.

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